Center Innovation Fund: JPL CIF

# Predicting deformation and cracking as a function of additive manufacturing process parameters

Completed Technology Project (2018 - 2019)

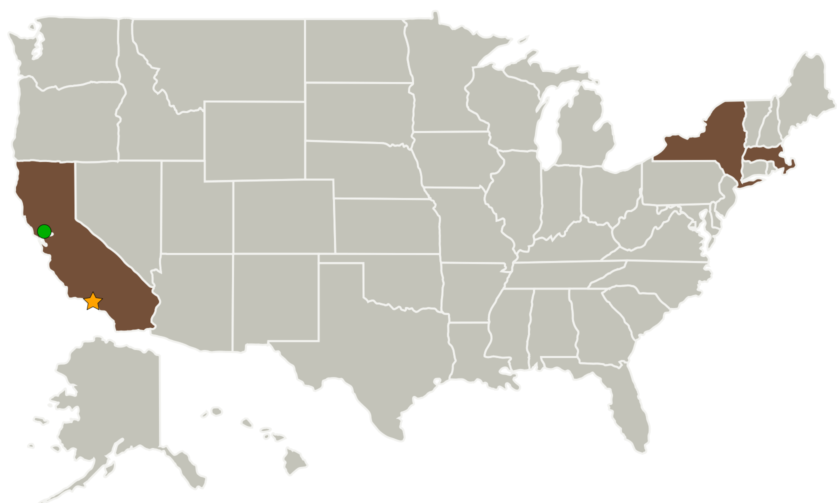
## Project Introduction

Combine part-level FEM model of residual stresses with CALPHAD-based phase transformation model to predict deformation and cracking due to thermal stresses, as well as precipitation of brittle intermetallic compounds, during the AM building process. Predict part level deformation and cracking during the Additive Manufacturing process. Optimize process parameters of the additive manufacturing process to reduce deformation, cracking, and residual stress and to mature additive manufacturing for part-level flight design applications.

## Anticipated Benefits

One of the challenges in additive manufacturing is that residual stresses induced during the build process can affect dimensional stability and, at the extreme, lead to fracture and failure. The ability to rapidly screen new designs for additive manufacturing, at the part-level, will dramatically accelerate the iterative design process for this technology, and may disrupt the trade space for existing technologies.

## Primary U.S. Work Locations and Key Partners

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Completed Technology Project (2018 - 2019)

| Organizations Performing Work | Role | Type | Location |
|---|---|---|---|
| ★Jet Propulsion Laboratory(JPL) | Lead Organization | NASA Center | Pasadena, California |
| ●Ames Research Center(ARC) | Supporting Organization | NASA Center | Moffett Field, California |

| Primary U.S. Work Locations | |
|---|---|
| California | Massachusetts |
| New York | |

## Project Transitions

**October 2018:** Project Start

**September 2019:** Closed out

**Closeout Summary:** The goal of this work was to mature a fast part-level additive manufacturing process simulation for prediction of residual stress, deformation and fracture during a build. Fully-coupled additive manufacturing process models must consider microstructural effects, but part-level simulation of microscopic features is computationally infeasible. The technical approach was to use scale-bridging surrogate models, i.e. a multi-scale and parallel computing modeling method, for computational efficiency. A ~120x reduction of part-level simulation time at constant model fidelity was demonstrated.

## Project Website:

https://www.nasa.gov/directorates/spacetech/innovation_fund/index.html#.VÇ

## Organizational Responsibility

**Responsible Mission Directorate:**

Space Technology Mission Directorate (STMD)

**Lead Center / Facility:**

Jet Propulsion Laboratory (JPL)

**Responsible Program:**

Center Innovation Fund: JPL CIF

## Project Management

**Program Director:**

Michael R Lapointe

**Program Manager:**

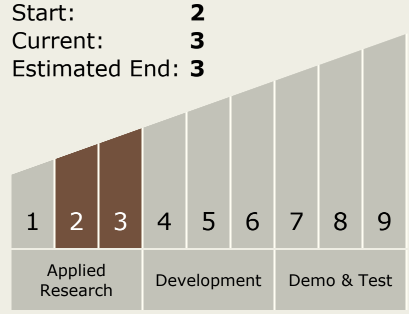
Fred Y Hadaegh

**Principal Investigator:**

Richard A Otis

## Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**



## Technology Areas

**Primary:**

- TX12 Materials, Structures, Mechanical Systems, and Manufacturing
  - └ TX12.1 Materials
    - └ TX12.1.2 Computational Materials

## Target Destination

Earth